

Ben's Garage: An Interactive and Immersive Risk Management Training Module for First-Year Engineering Students

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ABSTRACT

CONTEXT

Risk management is a foundational capability for engineers, yet it is often taught in a prescriptive and passive manner. From their very first year, engineering students should be actively engaged in identifying, assessing, and mitigating risks, whether in structured lab environments or while fabricating prototypes at home, where safety controls may be limited and the potential for preventable injuries remains high (ICA, 2016). Standards such as ISO 31000 offer a general framework for risk assessment, but students need engaging, authentic experiences to internalise the principles (Standards Australia/Standards New Zealand [SA/SNZ], 2018).

PURPOSE OR GOAL

The goal is to embed risk management as a core habit for engineering students from first year by developing Ben's Garage, an engaging, multi-platform simulation that immerses students in a virtual workshop. Through interactive scenarios, students learn to identify hazards, evaluate risks, and apply controls before undertaking hands-on projects, building confidence and safety awareness that grows throughout their degree and into industry practice.

APPROACH OR METHODOLOGY/METHODS

Using Unity3D and voxel assets, the application comprises four modules: (1) an ISO 31000 primer; (2) a game-based hazard identification and control activity; (3) a PPE selection task; and (4) a 360° image gallery for authentic practice. Planned evaluation includes pre/post hazard-identification tasks and student feedback analyses.

ACTUAL OR ANTICIPATED OUTCOMES

The implementation of Ben's Garage is expected to foster early and sustained engagement with risk management, particularly among first-year engineering students. Initial trials and tutor feedback indicate high levels of student interaction and improved understanding of hazard categories and control strategies. As students progress through the modules, they are anticipated to demonstrate measurable gains in hazard identification accuracy and increased confidence in applying appropriate controls before undertaking hands-on project work.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Game-informed immersive experiences can make risk principles tangible for novices. It was recommended to integrate "Ben's Garage" as a prerequisite to prototype building in first-year engineering, with future work extending to head-mounted VR and at-home web access.

KEYWORDS

Risk management; engineering education; virtual reality; simulation

Introduction

Engineering students frequently engage in hands-on prototyping, often in unsupervised home settings or semi-structured university workshops. These environments, while fostering creativity and autonomy, also present significant safety risks. Insurance data consistently show that a large proportion of preventable injuries occur in domestic contexts, with falls, lacerations, and thermal burns among the most common. For students, these incidents are not just inconvenient, they can disrupt learning, compromise wellbeing, and erode confidence in practical engineering tasks (ICA, 2016).

Embedding safety literacy early in the engineering curriculum is essential as a core competency. Students must develop not only technical proficiency, but also the situational awareness and risk management capabilities required to navigate real-world fabrication environments safely. However, traditional approaches to risk instruction are often prescriptive and didactic (Ross, 2011), limiting their transferability to authentic practice. A more integrated, experiential model is needed. A risk management exercise is needed that positions safety as a lived, context-sensitive skill embedded in design, prototyping, and everyday decision-making.

In recent years, game-based learning and gamification have emerged as influential pedagogical strategies in engineering education, offering novel pathways to enhance student engagement, motivation, and conceptual retention. While closely related, these approaches serve distinct educational functions: game-based learning employs structured games to teach specific content or skills, whereas gamification integrates game-like elements, such as points, levels, badges, and leaderboards into non-game contexts to incentivise participation and reinforce learning behaviours (Ramírez Ruiz et al., 2024; Triantafyllou et al., 2025; Celasun & Kaya, 2024; Adipat et al., 2021 and Lampropoulos and Sidiropoulos, 2024).

Gamification leverages both intrinsic and extrinsic motivators to enhance educational engagement. By integrating elements such as progress tracking, rewards, and structured challenges, educators can significantly increase student motivation and participation. These game-informed strategies foster a sense of achievement and ownership over learning, promote collaboration and healthy competition, and support differentiated instruction by enabling learners to progress at their own pace.

In engineering risk education, game-informed pedagogies offer a dynamic and emotionally resonant alternative to traditional didactic instruction. By embedding safety literacy, systems thinking, and ethical decision-making within interactive learning environments, these approaches personalise student pathways while reinforcing core competencies through sustained, authentic engagement.

Ben's Garage was developed through a design-based process to create a playful yet pedagogically rigorous learning environment for first-year engineering students at the University of Queensland. Implemented in Unity3D using stylised voxel assets, the system is accessible across Windows PCs, Android smartphones, and web platforms. Central to the experience is a physics-driven "active ragdoll" avatar named Ben, who provides humorous, consequence-based feedback when hazards are misclassified, while correct decisions restore the environment to a safe state. The tool functions as an immersive training tutorial, guiding students through the core principles of risk management: hazard identification, risk evaluation, and control implementation, in alignment with ISO 31000:2018 (SA/SNZ, 2018).

Engaging students with Ben's Garage is anticipated to foster transferable safety competencies applicable across both home-based prototyping and formal workshop environments, addressing a longstanding gap in early engineering education. By immersing learners in realistic scenarios that promote hazard recognition and practical risk assessment, the tool cultivates foundational safety literacy. Its design aims to reduce the frequency of preventable injuries, particularly those arising in unsupervised or semi-structured fabrication contexts where novice decision-making and limited oversight often intersect.

Software Platform Overview

Ben's Garage is structured into four sequential modules, each designed to scaffold the development of core safety competencies while aligning explicitly with course-level and program-level learning outcomes in undergraduate engineering education. The modular design supports progressive skill acquisition, from foundational awareness to applied decision-making.

Module 1: Framing Risk Awareness

Module 1 introduces students to risk literacy through a narrative simulation featuring Ben, a satirical avatar navigating a domestic garage setting. Designed as a familiar yet exaggerated figure, Ben's light-hearted misadventures serve to engage learners while maintaining psychological safety. Within this scenario, students are responsible for guiding Ben's actions during a routine fabrication task, identifying and mitigating a variety of real-time hazards, laying the foundation for practical safety awareness in engineering contexts.

To scaffold risk literacy, the module presents seven key hazard categories commonly encountered in workshop environments: biological (e.g., mould, bacteria), chemical (e.g., solvents, adhesives), electrical (e.g., faulty wiring), flammable (e.g., combustible materials), gravitational (e.g., falling objects), mechanical (e.g., moving parts), and behavioural (e.g., unsafe actions or lapses in judgement). This structured framework supports the development of situational awareness and a comprehensive safety mindset, bridging theoretical principles with practical application. By embedding decision-making within a relatable narrative, the module promotes early transfer of safety behaviours to both academic and real-world engineering contexts.

Figure 1(a) presents the learning interactive module that introduces students to the realities of health and safety through a visually engaging comparison of injury likelihood and severity using common tools, a drill and a chainsaw. By framing engineering as inherently risky and highlighting the dangers of unsupervised fabrication, it prompts students to reflect on their own practices and the importance of risk awareness. Figure 2(b) introduces students to structured risk assessment using a colour-coded matrix that evaluates the severity and likelihood of potential hazards. By applying the formula $Risk = Likelihood \times Consequence$, students can calculate a risk score and categorise it as low, moderate, or high. The visual example of a chainsaw, scored at 24 and flagged as high risk, reinforces the importance of evaluating both probability and impact before engaging in hands-on work.



Figure 1(a): Importance of Risk



Figure 1(b): Risk Assessment Matrix

Figure 2(a) presents a structured hierarchy of hazard mitigation strategies, categorised by effectiveness: Best, Better, and Good. It introduces six methods, removal, substitution, isolation, education, protective equipment, and behavioural awareness, each colour-coded and ranked to guide students in selecting appropriate controls. By visually reinforcing the principle that eliminating or substituting hazards is more effective than relying solely on personal behaviour or gear, the graphic supports the development of professional judgement and proactive safety planning. It serves as a pedagogical tool to scaffold students' understanding of control measures before engaging in hands-on engineering tasks. Figure 2(b) introduces engineering students to the core categories of hazards, biological, chemical, electrical, flammable, gravitational, mechanical, and behavioural, using clear visual icons and relatable examples. Alongside these categories, it defines essential terminology for risk classification, including hazard, risk, control, consequence, likelihood, and probability. By combining visual cues with concise definitions, the graphic scaffolds students' understanding of how hazards are identified, assessed, and managed. It serves as a foundational reference point for developing risk literacy and supports consistent language use across safety modules and project-based learning.



Figure 2(a): Risk Control Methods

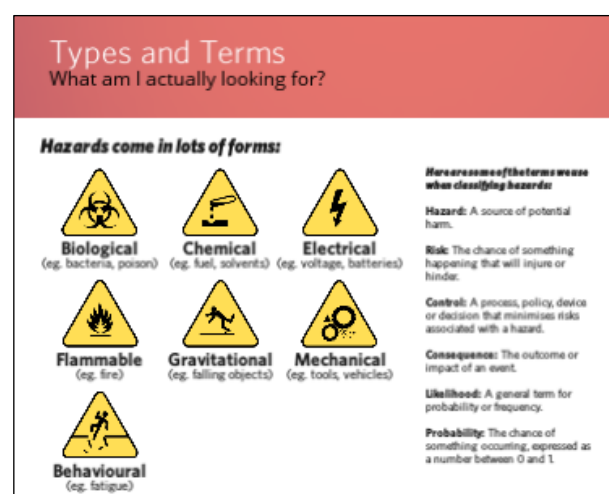


Figure 2(b): Hazard Classification

Module 2: Hazard Identification and Control

Module 2 deepens students' engagement with risk evaluation by placing Ben in a cluttered garage environment populated with dynamic hazards. Each simulation run randomly selects ten items from a predefined pool and transforms their state from safe to hazardous, requiring students to actively navigate the space, classify each hazard, estimate its likelihood and consequence, and select appropriate control measures.

Incorrect decisions trigger exaggerated but non-injurious feedback animations that illustrate mechanisms of harm, reinforcing the consequences of poor judgement in a psychologically safe manner. Correct actions restore the environment to a safe state, reinforcing effective risk mitigation strategies. A scoring system rewards accurate classification, control selection, and placement within a colour-coded risk matrix, with additional points awarded for first-attempt accuracy—encouraging precision and reflective decision-making.

The module includes a diverse range of hazards spanning biological, chemical, electrical, mechanical, and behavioural categories. Examples include bear traps, bleach bottles, car batteries, electric tools, gas cylinders, loose cables, venomous animals, and unstable equipment. This variety ensures broad exposure to realistic workshop risks and supports the development of analytical reasoning and professional judgement in line with ISO 31000:2018 principles.

The avatar, Ben, is randomly placed in the interactive garage scene. As Ben approaches items in the garage scene, the simulation pauses to prompt a structured assessment, requiring students to classify the hazard, estimate its risk level, and select an appropriate control measure.

Figure 3(a) presents an interactive challenging garage scene, where Ben engages in exaggerated physical activity within a hazard-marked zone. The playful setting, featuring common workshop items and humorous prompts, introduces students to risk awareness in a visually engaging and psychologically safe format. Figure 3(b) shows a hazard classification interface, where Ben encounters a simulated slip incident. The scene prompts students to identify the hazard type using a structured panel of categories. Figure 3(c) illustrates a hazard assessment interface, where students evaluate the likelihood of harm in a simulated workshop scenario. The dropdown menu prompts learners to select the likelihood of harm as part of a structured evaluation process. Figure 3(d) depicts a hazard severity assessment interface, where students evaluate the potential consequences of unsafe situation a cluttered workshop setting. The dropdown menu prompts learners to classify the degree of harm.

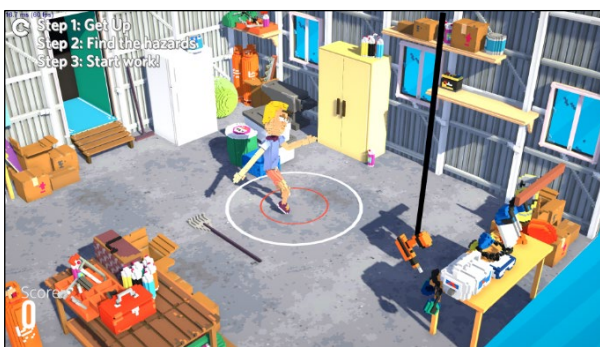


Figure 3(a): Interactive Garage Scene

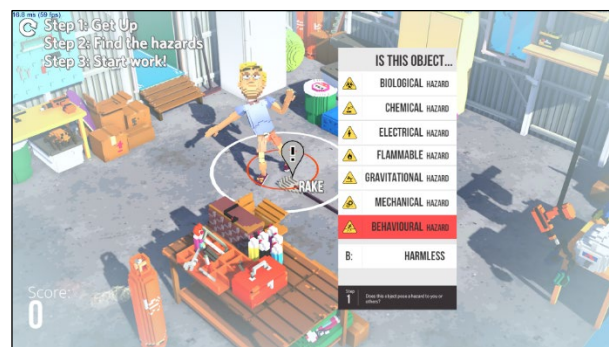


Figure 3(b): Hazard Identification Interface

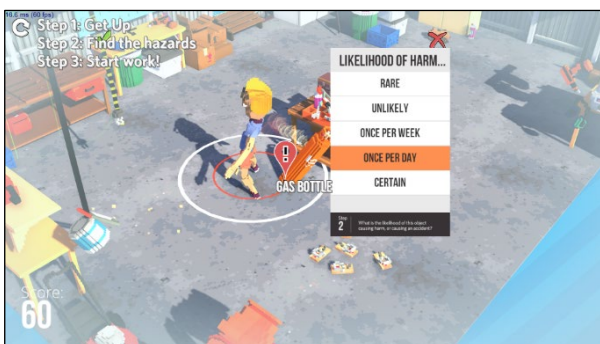


Figure 3(c): Likelihood of Harm Assessment

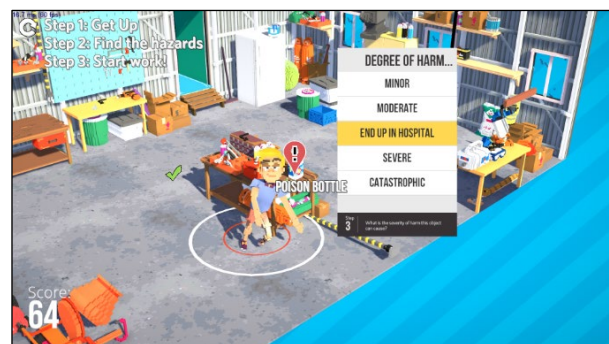


Figure 3(d): Degree of Harm Assessment

During gameplay, students are tasked with evaluating a series of hazards by classifying their type (e.g., chemical, biological, mechanical), estimating the likelihood and severity of potential harm, and selecting appropriate control measures. Correct assessments trigger immediate visual and auditory feedback, simulating the successful application of controls and neutralising the hazard within the environment. Misclassifications result in exaggerated, slapstick-style consequences, such as paint tins launching across the room, mousetraps snapping underfoot, or Ben being comically drawn into a cement mixer. These animated responses are intentionally non-injurious and serve to reinforce the mechanisms of harm in a psychologically safe and memorable format.

Upon completing Module 2, students guide Ben to his workstation to initiate a performance review. Each hazard encountered during the session is revisited, with visual indicators highlighting whether it was correctly identified, assessed, and controlled. Any missed hazards trigger a final, exaggerated chain reaction, sending Ben comically bouncing off around the garage, to illustrate cumulative risk and reinforce the importance of thorough assessment. This closing sequence

consolidates learning while enhancing engagement and replayability through humour, feedback, and reflection.

The performance review includes a structured scorecard that quantifies student accuracy across three key dimensions: hazard classification, risk matrix placement, and control selection. Each correctly assessed hazard earns up to 150 points: 50 per dimension, resulting in a maximum score of 1500 points per session. This scoring framework offers a clear benchmark for progress tracking and supports reflective learning through targeted, formative feedback.

Module 3: Personal Protective Equipment

Module 3 includes targeted activities focused on selecting appropriate Personal Protective Equipment (PPE) for specific workshop tasks involving tools such as drills, sanders, hand saws, and welding torches. Students outfit the avatar, Ben, with gear including goggles, respirators, welding masks, leather gloves, aprons, and earmuffs, exploring the relationship between task-specific hazards and corresponding protective measures. Correct selections prompt concise explanations of injury risks and required protection, while incorrect choices trigger immediate, illustrative feedback to reinforce learning. Figure 4(a) depicts Ben in a workshop environment surrounded by fabrication tools and a clearly displayed array of PPE options. Figure 4(b) shows Ben equipped with high-visibility safety gear, emphasising the importance of preparation and hazard-specific protection in engineering practice.



Figure 4(a): Available PPE



Figure 4(b): Used PPE

Students are provided with a selection of personal protective equipment (PPE) to appropriately outfit the avatar, Ben, for various workshop tasks. Each item is paired with a simulation of its protective properties, enabling learners to examine the relationship between specific hazards and corresponding safety gear. Table 1 summarises the available PPE options, organised by body region and aligned with typical injury prevention strategies.

Table 1. PPE options available in Module 3

Limb	Gear Name	Protection Offered
Head	Earmuffs	Noise
	Face Visor	Impacts, Sparks, Chemicals
	Hard Hat	Impacts
	Respirator	Dust, Fumes
	Safety Goggles	Impacts, Chemicals
	Welding Mask	Impacts, Sparks, Thermal, Bright Light
Body	High-Vis Vest	None
	Leather Apron	Sparks, Thermal, Chemicals
Hands	Leather Gloves	Sparks, Thermal, Chemicals

Module 4: 360° Image Gallery

The final module in Ben's Garage features an interactive image viewer that displays 360° spherical photographs of real-world garages in varying states of disarray. This component enables educators to embed authentic risk assessment tasks directly into coursework, encouraging students to apply the principles introduced in earlier modules to physical, unstructured environments.

The current version includes four immersive scenes, with additional images easily integrated as needed. Students explore each space by rotating the viewpoint, via click-and-drag or touch gestures, and zooming in to inspect details. Prompt text in the corner suggests hazard categories such as falling and trip risks, but students are free to identify and classify hazards independently, fostering open-ended engagement.

Figure 4 presents one such garage scene, densely packed with tools, equipment, and supplies. Shelves overflow with containers, power tools line the workbench, and exposed insulation and hanging cords contribute to a cluttered, high-risk environment.



Figure 4: 360° Garage Gallery Scene

Evaluation and Results

Initial trials of Ben's Garage were conducted within ENGG1100: Professional Engineering, the University of Queensland's flagship first-year course. Engaging over 1200 students annually, ENGG1100 challenges learners to design, build, and test a prototype that addresses a complex engineering problem. This makes the course an ideal context for embedding foundational safety and risk management skills.

The integration of Ben's Garage into ENGG1100 demonstrated strong student engagement, particularly in large cohorts where the tool fostered peer discussion and collaborative learning. Participants showed improved awareness of hazard types and expressed enthusiasm for future enhancements. Feedback from the initial deployment was overwhelmingly positive, affirming the tool's value in supporting early-stage engineering education.

The following feedback was provided by a tutor who was involved in the initial trials.

"In general, the feedback that we received from the students that came was very good, I felt like they generally learned quite a lot given that it was such a short class (but I definitely liked the format). The feedback we got (more from an ENGG1100 teaching standpoint) was generally that a lot of the students that came weren't aware that there were different types of risks (eg mechanical, biological, chemical etc).

In terms of the program, students loved it! They didn't have any negative things to say (at least not to me) and they all seemed to really enjoy the program. However, it did definitely work better in the classes that had

more people sign up, as there was more avenue for camaraderie and discussion (as a note for next year). The only real thing they asked for was VR goggles, but I know that they aren't around at the moment."

Ben's Garage integrates ISO 31000 with game-informed feedback to make invisible risks visible and memorable. Humorous, physics-based consequences offer low-stakes exposure to mechanisms of harm, aligning affective engagement with learning goals. Positioned prior to hands-on prototyping, the experience functions as an authentic, scalable prerequisite that promotes safer behaviours at home and on campus.

Conclusions

This paper presents Ben's Garage as a novel, game-informed simulation designed to embed risk management principles into first-year engineering education. Developed in alignment with ISO 31000:2018 and implemented within the University of Queensland's ENGG1100 course, the tool offers a multi-platform, modular experience that scaffolds safety literacy through interactive, consequence-driven learning.

Across its four modules, which are risk framing, hazard identification, PPE selection, and authentic image-based assessment, Ben's Garage operationalises core safety concepts in a psychologically safe and pedagogically engaging format. The use of stylised avatars, exaggerated feedback, and structured scoring mechanisms fosters emotional resonance and reflective practice, while maintaining academic rigour. Students demonstrated improved awareness of hazard categories, increased confidence in applying control measures, and strong engagement with the simulation's interactive elements.

Initial trials within ENGG1100 revealed that the tool not only supports individual learning but also enhances peer discussion and collaborative reasoning in large cohorts. Feedback from students and tutors affirmed its value as a scalable, low-barrier intervention that bridges theoretical frameworks with practical application. The potential for future integration with head-mounted VR and expanded image libraries further positions Ben's Garage as a flexible and extensible platform for safety education.

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